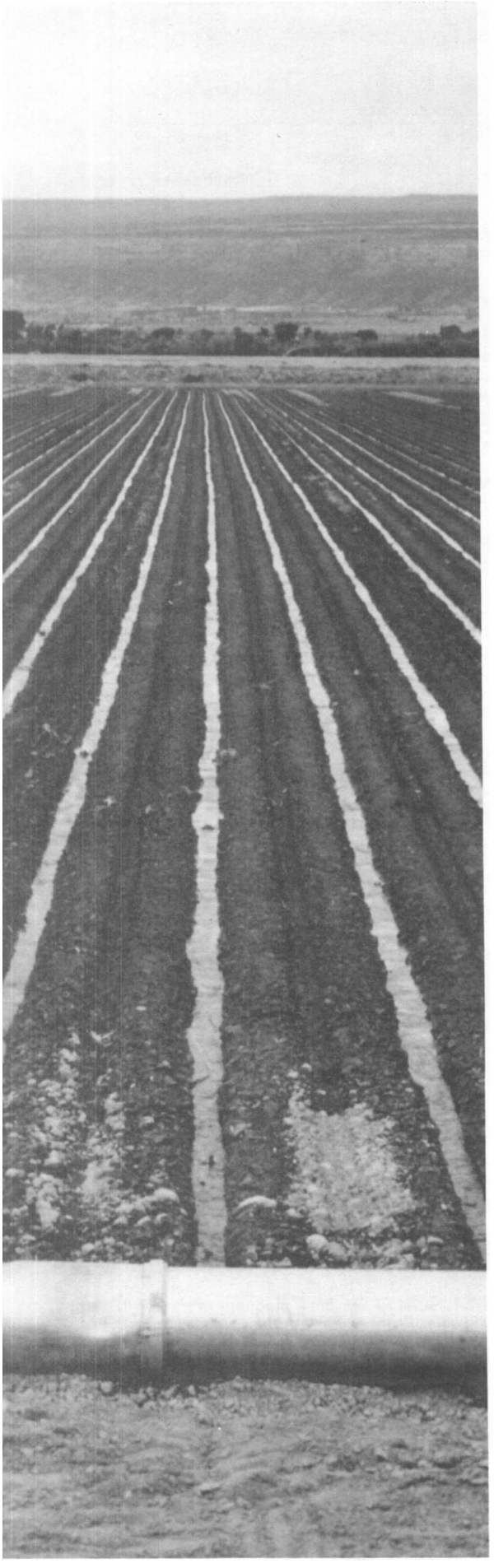

The impacts of limited water: A Colorado case study

By P. Lorenz Sutherland and John A. Knapp

INCREASED movement of people to the western United States has increased demands on a finite water resource. Today, most streams in the West are fully appropriated, and competition for water is increasing among economic sectors, neighboring river basins, and states.

Some people have suggested that the goal of public policy on water resources is to maximize productivity. To achieve this goal, water must be used efficiently to attain the highest value of use. Maximum economic efficiency of water thus occurs when water is transferred from less productive to more productive users (*12*).

Traditionally, agriculture accounts for more than 90 percent of western water consumption (*5*). The implications of struggles over water, which employ a market system of allocation, have been and are extensive. A case in point is population growth in Colorado, which is resulting in a higher demand for domestic water and the transfer of water from agricultural uses. The natural resource implications of such transfers include potentially accelerated soil erosion, lower agricultural productivity, and reduced options for land use.

The dramatic growth of Colorado's front range cities has increased domestic water demand (*19*); already, water has been transferred from thousands of acres of prime irrigated farmland. Between 1970 and 1980, for example, the population of Aurora increased 111 percent, by 83,614 people (*3*). During this same period, population in Colorado Springs jumped 59 percent, by 79,633 people. Average daily water use in Colorado Springs increased from 37.5 million gallons per day in 1970 to 50.9 million gallons per day in 1980, an increase of 15,037 acre-feet of water per year (*1*).

Because of their substantial growth and subsequent increase in water use requirements, Pueblo, Colorado Springs, and the Denver metropolitan municipalities have responded by acquiring water rights from irrigated agricultural regions including the Arkansas Valley in southeastern Colorado.

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A legal perspective

American water law doctrines fall into two general categories: riparian rights and prior appropriation rights. Both have different elements and attributes, but each is considered a property interest or right created or obtained under state law (*11*). The riparian doctrine generally dominates the law of water allocation and administration applied in states east of the 98th meridian. Under the riparian doctrine, owners of land adjacent to a body of water possess an equal right of water use.

For the 18 states west of the 98th meridian, the doctrine of prior appropriation is the primary law of water allocation and administration (*13*). While the riparian doctrine is associated with English common law of the 1820s, the doctrine of prior appropriation developed in response to needs of the mining industry. Nine states have statutory provisions in which the doctrine appears in "pure" form, sometimes referred to as the Colorado Doctrine. These states, other than Colorado, include Alaska, Arizona, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming. The remaining nine states conform to statutory provisions considered "hybrid" systems (*6*) in which both recognized riparian and prior appropriation rights exist, often referred to as the California Doctrine. California, Kansas, Nebraska, North Dakota, South Dakota, Oklahoma, Oregon, Texas, Washington, and one eastern state, Mississippi, make up this group.

Development of the prior appropriation doctrine in Colorado can be traced to five stages: the Colorado gold rush, the Jefferson territorial legislation of 1859, federal statutory provisions of the 1866 Mining Act, the Desert Land Act of 1877, and the adoption of the Colorado Constitution (*6*). Colorado miners applied the rule of mining claims to the diversion and use of water (*17*). It seemed only reasonable that under the semiarid conditions of the West, with limited water and the necessity of maintaining

order during the gold rush period, the first divertor of water had a prior right; hence, the phrase, "first-in-time, first-in-right." The doctrine was further enhanced by enactment of resolutions by the ruling forces of the organized "de facto" mining districts that specified certain water rights (*13*).

As settlement of the West continued, the concept became accepted by those who developed water for irrigated agricultural purposes. The Colorado Constitution, adopted in 1876, contained four sections in Article XVI on the use of water that has served the citizenry of Colorado for 112 years. These sections affirmed that water of every natural stream was property of the public and subject to prior appropriation, reserved the right to divert water from the source so long as the use was beneficial, and identified preferential uses. A series of additional laws was passed governing water right acquisition and administration in 1879, 1881, 1903, 1919, 1943, and 1969.

Of particular importance today is the fact that new surface water right applications and changes of existing water rights, including changes in point of diversion, place of storage, type of diversion, or time of use, are reviewed by the water court. An important feature of a "pure" prior appropriation doctrinal system, like Colorado's, is that water right conflicts are resolved through a judicial-adversarial process. Colorado is divided into seven water divisions representing the primary river drainage basins. Each is administered by a division engineer and each has a water court consisting of a district court judge and a court-appointed referee.

There are several attributes of Colorado water law that relate directly to land use changes resulting from water right litigation. First, because a water right is a real property right, not appurtenant to a given land parcel, it can be transferred by trade (exchange), lease, or sale. However, water rights may be conveyed along with land in a real estate transaction. In this case, no change in point of diversion, preference, or time of use occurs; therefore, the water right transfer circumvents legal procedures. When a water right is severed from the land—conveyed to a new use and a new point of diversion, as in most transfer cases involving municipalities—it becomes a transfer, and permission for change is required.

A second important attribute held by the courts, a change in water rights in which the burden of proof would rest with the applicant, will not be permitted if a transfer adversely affects a vested right of another appropriator in quantity [Farmers Highline Canal & Reservoir Co. v. City of Golden, (129 Colo. 575, 1954); Danielson v. Kerbs Ag. Inc., (646 P. 2d 263, 372, 1982)] or unreasonable deterioration of water quality [A-B Cattle Co. v. United States (589 P 2d 57, 60, 1978)]. A water right transfer may adversely affect an appropriator in terms of water quantity, in one or more ways: a change in point of diversion or point of storage results in the lack of reliability or availability of water, diminished return flow to downstream appropriators that may have previously been depended upon to exercise a vested water right, or a change in time of use.

Third, only the quantity of water equalling the historic consumptive use may be transferred. This amount may be equal to, but generally is less than, the original appropriated quantity. Historic consumptive use is considered as the amount of water lost out of a given drainage basin by crop evapotranspiration, domestic consumption (lawns, gardens), and manufacturing processes (*14*). Consumptive use may also include nonbeneficial losses from the system, such as evaporation from canals and ditches.

The Arkansas Valley setting

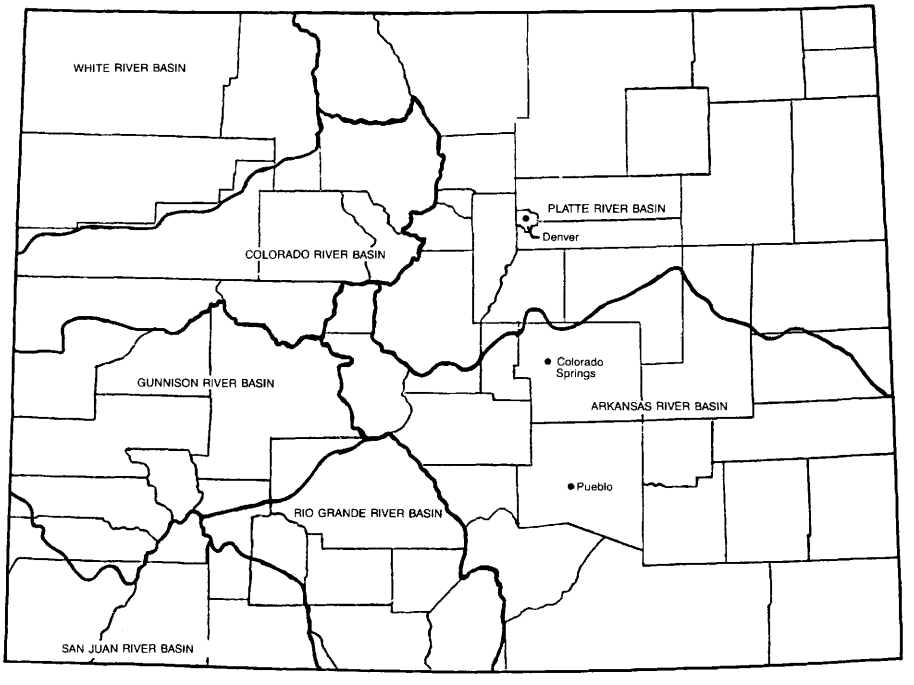
The Arkansas Valley originates upstream from Leadville, Colorado, at an elevation of more than 14,000 feet. A notable feature of the river basin, which encompasses about 26,150 square miles, is that its headwaters are at the highest point in Colorado. The river leaves the state downstream about 340 miles at the lowest point of less than 3,400 feet elevation (*9*).

Weather in the upper reach of the valley is characterized by 14.7 inches of annual precipitation and an average annual temperature of 35°F. The foothills region of the valley enjoys 12.7 inches of annual precipitation and an annual temperature of 54°F. The river leaves the foothills and flows across the middle reach of the plains, an area with 10.3 inches of annual precipitation and an average temperature of 53°F. The lower reach of the valley is characterized by 14.5 inches of precipitation and an annual temperture of 54°F.

Within the irrigated plains area of the valley, the soils consist primarily of 11 associations. The geographic area where water is currently being removed is dominated by the Rocky Ford-Numa-Kornman association, which developed from both Pleistocene and Recent alluvial deposits. Soil subgroups in this association include Ustic Torriothents, Ustollic Calciorthids, and Ustic Torrifluvents.

The Spanish were the first to explore the Arkansas Valley between 1760 and 1780. Lieutenant Zebulon Pike made the first exploration for the United States in 1806, followed by Captain J. C. Fremont and Captain J. W. Gunnison. The first settlements were established after the Colorado gold rush. Farming began in the Arkansas Valley River Basin with development of the Bessemer and Rocky Ford Highline Canals as major water delivery systems. The second major development occurred when J. W. Prowers started the livestock industry by bringing 100 head of cattle into the valley in 1862. According to Southeastern Colo-

River and water divisions in Colorado.



rado Water Conservancy District records, 30,000 head of cattle from Texas were in the Arkansas Valley by the end of 1870.

The Rocky Ford Ditch Company canal construction project was initiated in 1873 and completed in 1880, irrigating some 10,000 acres (*4*). By 1887, the larger Catlin Canal was completed, adding an additional 25,000 acres of land for irrigation. Rangeland above these canals was sold by the government for $1.25 per acre. Irrigated land values ranged from $20 to $60 per acre. By this time, the population in Rocky Ford had doubled, and by 1898 school enrollment had increased fourfold.

Three of the first crops were alfalfa, first grown in 1875; watermelon, first grown in 1878; and cantaloupe, first grown in 1884 (*4*). In 1896, the Rocky Ford Melon Growers Association was organized to bring growers together into one marketing group. Melons were shipped with the brand name "Rockyford" cantaloupe, a name that remains known across the country.

By 1905, four seed companies had developed businesses in Rocky Ford. By 1907, one of these, the Rocky Ford Seed Breeders Association, was selling 30 tons of cantaloupe seed a year to growers in the Imperial Valley of California. The honeydew melon also had its origin in the Arkansas Valley. By 1925, 90 percent of the cucumber seed and 75 percent of the cantaloupe seed planted in the United States were grown in Otero County (*4*). However, the perishability of these commodities and price fluctuations led farmers to seek a more diversified irrigated agriculture. The crop introduced to fill this void was the sugar beet.

Much of the original irrigation development and its ultimate decline has been tied in part to the sugar beet industry. Financial backers of the sugar factories supplied substantial capital to complete the canal projects. Irrigation seemingly insured against crop failure, and beets provided farmers with a reliable cash crop.

The first sugar factories, Rocky Ford and Sugar City, opened in 1900 with plans for several other factories and irrigation developments along the river. Over 15 miles of irrigation canals, 750 miles of laterals, and a 14,000-acre storage reservoir were built by William M. Wiley between 1900 and 1905 at a cost of $3 million. By 1905, factories in Swink and Holly were completed (*8*). At the peak of the industry, 22 facilities operated in southeastern Colorado.

Ultimately, the valley had more factories than the farmers and land were able to support. Labor supply, a problem because production of one acre of beets required more than 100 man-hours, was in part fulfilled with German-Russian, Mexican, and Japanese immigrants. By 1913, three factories had closed because of lower yields caused by poor quality irrigation water and sugar pricing problems. Subsequently, beet blight ("curly top"), short irrigation supplies, and extremely low post-war sugar prices sharply reduced or eliminated profits. All but one of the factories had closed by 1967. Closure of the last factory in the Arkansas Valley at Rocky Ford occurred in 1979 in the face of overall lower financial returns to agriculture (*10*).

Although the "Rocky Ford" cantaloupe and sugar beet were largely responsible for development of the Arkansas Valley, other crops proved adaptable to the area. Crops that have been or are currently grown include corn, grain sorghum, alfalfa, soybeans, dry beans, wheat, onions, tomatoes, watermelons, honeydews, cucumbers, eggplants, cabbage, sweetcorn, chilles, grapes, cherries, raspberries, apples, blackeyed peas, cantaloupes, pumpkins, squash, okra, and zinnia flowers for seed. Two seed companies remain as leaders in the development, culture, and marketing of curcurbit and other specialty seeds worldwide. Melon development continues, as well. The "Rocky Sweet," a cross between a cantaloupe and honeydew was grown commercially for the first time in 1985.

It was first recognized in 1922 that both rural and urban futures in the Arkansas Valley depended upon a properly managed water supply. Systems developed by the Twin Lakes Reservoir and Canal Company in the 1930s diverted water from the west side of the Rocky Mountain Continental Divide through a four-mile tunnel. In 1958, the Southeastern Colorado Water Conservancy District was established to serve municipal and industrial, irrigation, power generation, flood and sediment control, and recreational concerns and to develop transmountain diversions for additional water supplies. In 1962, Public Law 87-590 authorized the construction and operation of the multipurpose project called Fryingpan-Arkansas Water Project. Construction started in 1962 and culminated in 1984 with the completion of a second power generation unit at the Mt. Elbert power plant (*16*).

Adjudicated direct water flow rights, nontributary to the Arkansas River, total 7,326.1887 cubic feet per second in the basin. The first water right decree came in April 1861, the last in February 1933. The basin includes eight transmountain diversions, two electrical generating plants, and 15 major reservoirs with a total useable capacity of about 1,861,830 acre-feet. Average annual water yield native to the basin between 1968 and 1972 was about 943,500 acre-feet (*9*). Since 1972, the Fryingpan-Arkansas Water Project has developed and allocated 416,744 acre-feet, about 27,785 acre-feet of additional water per year.

In years of high snow pack, the basin is underappropriated. In average years, according to Donald Miles, area irrigation engineer with the Colorado Cooperative Extension Service, the basin is overappropriated, with shortages up to 40 percent.

The maximum number of acres served in the intensely irrigated plains region below Pueblo Reservoir is about 304,900. All of the area served by the Arkansas River is surface-irrigated. Water is diverted from the mainstream, delivered through open channels, and distributed to individual farmers through laterals. On-farm water use-efficiency averages 40 to 50 percent, according to Miles.

Poor water quality has been a factor in reduced agricultural productivity in the Arkansas Valley. Concentrations of total dissolved salts as high as 5,000 parts per million have frequently been observed (*9*). Maximum values range from 770 to 5,100 parts per million, with the highest level observed in the lower reaches of the river.

A restructuring of land use

As in other agricultural areas, rural Colorado has suffered economic difficulties in recent years. Loss of agribusinesses, cropping options, and irrigation itself has led to a downturn in tax bases, jobs, and absolute populations. The net loss in population between 1970 and 1980 was about 1,054 people (4.1 percent) in Otero and Crowley Counties, where major water transfers have occurred (*2*). Statewide, Colorado had a net gain of 680,368 people, a 30.8 percent increase, during the same period.

In parts of the basin, farmers are taking advantage of the rights under Colorado's prior appropriation doctrine, depending upon water rights sales for economic survival. The water is being transferred to support urban growth, both within and outside of the basin. In the three 1986 transfers involving water rights to 16,850 acre-feet of water per year, the negotiated average price was $2,625 per acre-foot, a total of about $44.2 million. The maximum price paid was about $3,500 per acre-foot (*16*).

The transfer of irrigation water to domestic uses has been gradual until recent years. The first major water rights sale occurred in 1965. It resulted in the withdrawal of 4,500 acres under the Otero canal from agricultural production. This sale was followed by the water rights transfers of the Las Animas Town Ditch in 1970 and the Booth-Orchard-Grove Canal in 1972. Sales of the Colorado Canal water rights occurred in

three separate transfers. The first, in 1973, resulted in water removal from 13,000 acres; the second, in 1985, from 13,500 acres; and the third, in 1986, from 14,000 acres—a total of 40,500 acres. Two other major transfers, Las Animas Consolidated in 1982 and Rocky Ford Ditch Majority in 1986, affected an additional 9,550 acres. About 58,000 acres, therefore, have lost irrigation water as a result of these transfers to domestic uses over the past 20 years. This represents 18 percent of the original irrigated land in the basin, principally from six canal systems. Fifty-nine percent of that area is considered prime agricultural land, those with soil types best suited for irrigated crop production (*18*). In Crowley County, where the greatest transfer activity has occurred, at least 43,000 acres—92.5 percent of the irrigated land—has had the water rights sold, and, in many cases, water removed.

Land removed and potential land removal from irrigated agricultural production in the Arkansas Valley of Colorado

Irrigation Canal System	Land Removal From Irrigation (acres)	Prime Land (%)	Potential Land Removal From Irrigation (acres)	Prime Land (%)
Booth-Orchard-Grove	1,500	20		
Huerfano-Cacharus			5,000	0
Bessemer			18,500	95
Rocky Ford Ditch	4,600	40		
Rocky Ford Minority			3,000	64
Otero Canal	4,500	40		
Holbrook			14,944	95
Colorado Canal	40,500	65	3,289	65
Las Animas Town Ditch	1,950	35		
Consolidated Ditch	4,950	60		
Fort Lyon			56,633	88
Fort Bent/Keesee			6,801	19
Amity			27,827	75
Total	58,000	59	135,994	72

At least one more major water transfer will likely occur between 1987 and 1990, bringing the total acreage affected to 73,000.

An additional 135,994 acres have the potential for being removed; 72 percent of these acres are considered prime cropland. Shareholders of these canal systems have taken action that would allow pursuance of transfer. But further transfers may be limited because the water transfers that have occurred or currently are being negotiated may fulfill the anticipated demand for front-range metropolitan areas. The remaining water also is low in quality, and the exchange of water upstream for an out-of-basin transfer could potentially leave reaches of the river dry, which is against state-mandated minimum streamflow.

Implications for land use change

Alternate land uses for the remaining farmland after irrigation water is removed are limited. The potential for soil erosion by wind is dramatically increased, and natural precipitation levels cannot support reliable dryland cropping. Historically, wind erosion has been a severe problem. A serious dust storm occurred in February 1977 (*15*). Data from GOES-1 and SMS-2 satellites showed that the airborne soil plume covered more than 248,000 square miles. Within 48 hours, it had reached the Atlantic Ocean, and after 72 hours, the upper air currents had carried the airborne soil over the mid-Atlantic. The soil origin also had been located: eastern New Mexico and southeastern Colorado, specifically from two counties, Kiowa and Crowley. As previously mentioned, Crowley County is where the greatest water removal is occurring. With irrigation and typical cropping systems, soil loss via wind erosion varies from 3 to 6.5 tons per acre annually. With the loss of irrigation, protective residue cover falls below the adequate level. Soil removal by wind results in losses in excess of 15 tons per acre annually, three times the acceptable loss.

Agricultural water is being removed from other areas of Colorado with less dramatic consequences than in the more arid area of southeastern Colorado. Water removal from irrigated mountain meadows in the central Rocky Mountains has led to a relatively smooth conversion to less productive dry pasture or rangeland. About 21,000 acres or 80 percent of the irrigated pasture and hayland in South Park has been removed from irrigated production, according to Eugene Siemer, superintendent of the Colorado State University Mountain Meadows Research Center in Gunnison. Likewise, deep-well irrigation from the Ogallala aquifer has declined in much of the Colorado high plains. Of the area in southeastern Colorado, about 34,000 acres, where precipitation exceeds 14 inches annually, have been converted to dryland agriculture without dramatic natural resource implications.

What response to reallocation?

Restructuring land use following loss of irrigation presents the limited options of abandonment, conversion to dryland agriculture, or revegetation to permanent rangeland with limited livestock use.

General abandonment of the land occurred following the earliest water rights transfers. As discussed, abandonment has led to extremely erodible, essentially valueless wasteland. Conversion to dryland crop production can be successful in areas where precipitation exceeds 14 inches a year and where wind erosion can be kept to acceptable levels with appropriate conservation practices, including windbreaks, contour farming, stripcropping, conservation tillage, and crop rotation. In areas of low precipitation and high atmospheric demand, conversion to rangeland through revegetation is the ultimate solution to wind erosion.

A common assumption is that previously irrigated land can be easily and adequately revegetated to permanent cover. However, revegetation in the arid Great Plains has been less than 50 percent successful, and in southeastern Colorado the percentage is nearer 35. With natural precipitation and weed competition as constant limitations, native perennial species—blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), sideoats grama (*Bouteloua curtipendula*), and western wheatgrass (*Agropyron smithii*)—are slow to revegetate on soils altered by irrigation through sedimentation and increased salinity, even when seeded under ideal conditions.

Success varies by soil type and is limited to the more coarse soils. Species showing the most promise for establishment and resistance to drought and salinity are western wheatgrass, galleta (*Hilaria jamesii*) and Russian wildrye (*Elymus junceus*) (*7*).

Successful revegetation has involved the use of cover crops prior to grass seeding, a firm seedbed, species native to rangeland in the area, and an aggressive weed control program. Typical cost, if successful the first time, ranges from $40 to $60 per acre.

Revegetation may be decreed voluntary or assisted through U.S. Department of Agriculture programs. Decreed revegetation has been used by Colorado water courts in recent irrigation water transfers as a legal instruction in the transfer agreements. For

example, in the Colorado Canal water removal case, the directive read as follows:

"Prior to removing water from any land now irrigated in order to affect a transfer of that water to municipal or other non-irrigation use, the transferring shareholder shall place into effect a program whose goal will be the establishment of a ground cover of a type which will not require irrigation after its establishment, in order to mitigate the blowing of sand, dust, or the proliferation of noxious weeds. A shareholder who intends to transfer water to municipal or other non-irrigation use will not plow up irrigated land covered with a perennial such as alfalfa. Notice of removal of water from land now irrigated shall be given to the Proxy Group at least two years prior to the effective date of such removal. Upon such notice, a field investigation shall be accomplished and a revegetation program designed by a recognized, experienced professional crop scientist or agronomist selected by the party responsible for the revegetation program...."

In this particular situation, the municipality that purchased the water rights is the party responsible for the revegetation.

One unique approach is the voluntary establishment of a consortium of interested entities, including water rights buyers and sellers and research and resource action agencies at various levels, that has evolved into a coalition to provide political and monetary support. Included are the cities of Pueblo, Colorado Springs, and Aurora; Public Service Company of Colorado; landowners; Colorado Soil Conservation Board; the Crowley-Otero Association of Conservation Districts; Colorado State University, and the Soil Conservation Service. This consortium, led by SCS, has pooled financial and human resources to evaluate plant materials, seeding and cover crop techniques and timings, and weed control options, which are largely unanswered issues. The project, set up for five years, has the objective of developing technical answers on successful revegetation and the conversion of irrigated land to permanent rangeland.

As far as the availability of federally assisted programs is concerned, the USDA's Great Plains Conservation Program offers revegetation incentives through an 75 percent cost-share for seeding and associated costs of revegetation. Another program, the Agricultural Conservation Program, likewise provides 50 percent to 75 percent cost-sharing for revegetation. Third, the Conservation Reserve Program provisions of the Food Security Act of 1985 provide an incentive to eligible producers willing to retire highly erodible land from agricultural commodity production for 10 years, converting these lands to rangeland. In Colorado, about 1.7 million acres have been enrolled to date.

The future

Transfer of irrigation water to other uses in Colorado and the West poses challenging land resource, economic, and social questions. In Colorado, agricultural water is the most readily available source for conversion to urban uses. The senior water rights, with the greatest potential for transfer and generally the best water quality, have been selected for transfer. Lack of current legal limitations under the "pure" prior appropriation doctrine of water allocation has allowed water transfers without concern for the adverse effects in terms of social, economic, and water quality impacts. Although there is precedence for considering water quality, "unreasonable deterioration" has not been defined.

Colorado water courts recent transfer decrees in the Arkansas Valley have considered the impacts of wind erosion in the water rights transfer process. Revegetation of highly erodible land no longer irrigated has become an important precedent in the evolution of the prior appropriation doctrine.

At least two unanswered questions remain at this point:

1. How far into the future does the liability of the party responsible for revegetation go and is that party responsible for maintaining the rangeland, say for 20, 30, or more years?

2. If revegetation is unsuccessful even though the responsible party has proceeded in good faith and used the best available technology, should the water rights decree be voided and water transferred back to its original agricultural use since revegetation was a legal condition of the decree?

Water quality must be considered in assessing the adverse effects of appropriators in future water transfer cases. Moreover, a monetary assessment should be considered on each water transfer, then put into a special fund to support rural development programs to counteract the social and economic consequences of the water transfer. It has been suggested that cash bonds similar to those set in mined-land reclamation be posted to assure that revegetation is done with due diligence. However, bonds probably will not be required because the mandated revegetation is a condition of the water transfer.

Climatic constraints limit conversion of land from irrigated to dryland production, leaving revegetation for rangeland as the only option to total abandonment. In response, innovative financial, political, and technical coalitions are searching for answers to land use restructuring in the Arkansas River Basin as urban-suburban growth continues to exert pressure on irrigated agricultural resources.

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